

1 WHAT IS CLAIMED IS

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1. An optical semiconductor device,
comprising:

a substrate of SiC having a first
conductivity type;

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a buffer layer of AlGa_N formed on said
substrate epitaxially, said buffer layer having said
first conductivity type and a composition represented
by a compositional parameter x as $Al_xGa_{1-x}N$;

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a first cladding layer having said first
conductivity type, said first cladding layer being
formed on said buffer layer epitaxially;

an active layer formed epitaxially on said
first cladding layer;

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a second cladding layer having a second,
opposite conductivity type, said second cladding layer
being formed on said active layer epitaxially;

a first electrode provided so as to inject
first-type carriers having a first polarity into said
second cladding layer; and

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a second electrode provided on said
substrate so as to inject second-type carriers having
a second polarity,

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said buffer layer containing said first type
carriers with a concentration level in the range from
 $3 \times 10^{18} \text{cm}^{-3}$ to $1 \times 10^{20} \text{cm}^{-3}$ and said compositional
parameter x larger than 0 but smaller than 0.4 ($0 < x$
< 0.4).

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2. An optical semiconductor device as

1 claimed in claim 1, wherein said substrate contains
carriers of said first conductivity type with a
concentration level in the range from 1×10^{18} - $1 \times$
5 10^{20} cm^{-3} .

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3. An optical semiconductor device as
10 claimed in claim 1, wherein said compositional
parameter x of said buffer layer is less than 0.09 (x
< 0.09).

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4. An optical semiconductor device as
claimed in claim 1, wherein said substrate has a
(0001)Si surface of SiC and wherein said buffer layer
20 is formed on said (0001)Si surface in intimate contact
with said substrate.

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5. A method of fabricating an optical
semiconductor device, comprising the step of: growing
an AlGa_xN film having a composition of $\text{Al}_x\text{Ga}_{1-x}\text{N}$ ($0 < x$
< 0.4) on an SiC substrate by a metal-organic vapor
30 phase epitaxy process, under a pressure of about 90
Torr or less.

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6. An optical semiconductor device,
comprising:

- 1 a substrate of SiC having a first conductivity type;
a buffer layer of AlGa_N formed on said substrate epitaxially;
- 5 a first cladding layer of AlGa_N having said first conductivity type, said first cladding layer being formed on said buffer layer epitaxially;
an optical waveguide layer of Ga_N having said first conductivity type, said optical waveguide layer being formed on said first cladding layer epitaxially;
- 10 an active layer formed epitaxially on said optical waveguide layer, said active layer containing Ga as a group III element and N as a group V element;
- 15 a second cladding layer of AlGa_N having a second, opposite conductivity type, said second cladding layer being formed on said active layer epitaxially;
- a first electrode provided so as to inject first-type carriers having a first polarity into said second cladding layer; and
- 20 a second electrode provided on said substrate so as to inject second-type carriers having a second polarity,
- 25 said substrate having a top surface separated from a bottom surface of said active layer by a distance of about 1.6 μm or more.

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7. An optical semiconductor device as claimed in claim 6, wherein said buffer layer has a composition represented by a compositional parameter x as Al_xGa_{1-x}N, said first cladding layer has a composition represented by a compositional parameter y as Al_yGa_{1-y}N, and said second cladding layer has a
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1 composition represented by a compositional parameter z
as $\text{Al}_z\text{Ga}_{1-z}\text{N}$, said compositional parameter x having a
value equal to or larger than 0.08 but smaller than
0.5 ($0.08 \leq x < 0.5$), said compositional parameter y
5 having a value equal to or larger than 0.05 but equal
to or smaller than said compositional parameter x
($0.05 \leq y \leq x$), said compositional parameter z having
a value smaller than said compositional parameter y (z
< y).

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8. An optical semiconductor device,
15 comprising:
a substrate of SiC having a first
conductivity type;
a first cladding layer having a first
conductivity type, said first cladding layer being
20 formed on said substrate epitaxially;
an active layer formed epitaxially on said
first cladding layer;
a second cladding layer having a second,
opposite conductivity type, said second cladding layer
25 being formed on said active layer epitaxially;
a third cladding layer having said second
conductivity type, said third cladding layer being
formed on said second cladding layer epitaxially;
a first electrode provided so as to inject
30 first-type carriers having a first polarity into said
second cladding layer; and
a second electrode provided on said
substrate so as to inject second-type carriers having
a second polarity,
35 said third cladding layer having a ridge
structure,
wherein an insulating film is interposed

1 between said second cladding layer and said third
cladding layer, said insulating film having an opening
in correspondence to said ridge structure, with a
width smaller than a width of said ridge structure.

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9. An optical semiconductor device as
10 claimed in claim 8, wherein said contact layer covers
a top surface and both side walls of said ridge
structure continuously.

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10. An optical semiconductor device as
claimed in claim 9, wherein said first electrode
covers a top surface and both side walls of said
20 contact layer, corresponding respectively to said top
surface and both side walls of said ridge structure,
continuously.

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11. An optical semiconductor device as
claimed in claim 10, wherein said ridge structure is
formed in a recess structure exposing said insulation
30 film, and wherein said first electrode fills said
recess structure.

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12. An optical semiconductor device as
claimed in claim 10 wherein said third cladding layer

1 is formed of a nitride of a group III element.

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13. An optical semiconductor device,
comprising:

a substrate of SiC having a first
conductivity type;

10 a first cladding layer having a first
conductivity type, said first cladding layer being
formed on said substrate epitaxially;

an active layer formed epitaxially on said
first cladding layer;

15 a second cladding layer having a second,
opposite conductivity type, said second cladding layer
being formed on said active layer epitaxially;

a third cladding layer having said second
conductivity type, said third cladding layer being
20 formed on said second cladding layer epitaxially;

a contact layer of said second conductivity
type, said contact layer being formed on said third
cladding layer;

25 a first electrode provided on said contact
layer;

a second electrode provided on said
substrate;

said third cladding layer forming a ridge
structure having a T-shaped cross-section,

30 said third cladding layer including, at a
bottom part thereof, a pair of cuts, such that said
cuts penetrate from respective lateral sides of said
ridge structure toward a center of said ridge
structure.

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1 14. A method of fabricating a semiconductor
device, comprising the steps of:
 forming an insulation pattern on a
semiconductor layer such that said insulation pattern
5 has an opening; and
 forming, on said insulation pattern, a
regrowth region of a nitride of Al and a group III
element in correspondence to said opening,
 said step of forming the regrowth region
10 being conducted by an metal-organic vapor phase
epitaxy process.

15 15. A method as claimed in claim 14,
wherein said step of forming said regrowth region
includes the step of admixing a halogen to a source
material used in said metal-organic vapor phase
20 epitaxy process for forming said nitride.

25 16. A method as claimed in claim 15,
wherein said step of forming said regrowth region
includes the step of supplying said halogen to a
reaction chamber of a metal-organic vapor phase
deposition apparatus, in which said metal-organic
30 vapor phase epitaxy process occurs, separately to a
gaseous source of nitrogen.

35 17. A method as claimed in claim 14,
wherein said step of forming said regrowth region is

1 conducted by using a metal organic compound containing
halogen.

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18. An optical semiconductor device,
comprising:

a substrate;

10 a first cladding layer of a nitride of a
group III element formed epitaxially on said
substrate, said first cladding layer having an n-type
conductivity;

15 a first optical waveguide layer of a nitride
of a group III element formed epitaxially on said
first cladding layer, said first optical waveguide
layer having an n-type conductivity;

20 an active layer of a nitride of a group III
element formed epitaxially on said first optical
waveguide layer;

an electron blocking layer of a nitride of a
group III element formed epitaxially on said active
layer, said electron blocking layer having a p-type
conductivity;

25 a second optical waveguide layer of a
nitride of a group III element formed epitaxially on
said electron blocking layer, said second optical
waveguide layer having a p-type conductivity;

30 a second cladding layer of a nitride of a
group III element formed epitaxially on said second
optical waveguide layer, said second cladding layer
having a p-type conductivity;

35 a contact layer of a nitride of a group III
element formed epitaxially on said second cladding
layer, said contact layer having a p-type
conductivity;

a first electrode provided on said contact

1 layer; and

a second electrode provided on said substrate;

5 each of said electron blocking layer, said second optical waveguide layer and said second cladding layer being doped by Mg;

wherein said second optical waveguide layer and said second cladding layer contain Mg therein with a concentration level lower than a concentration level of Mg in any of said electron blocking layer and said contact layer.

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19. An optical semiconductor device as claimed in claim 18, wherein said second optical waveguide layer and said second cladding layer contain Mg with a concentration level not exceeding $4 \times 10^{19} \text{cm}^{-3}$.

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20. An optical semiconductor device as claimed in claim 19, wherein said electron blocking layer and said contact layer contain Mg with a concentration level exceeding $4 \times 10^{19} \text{cm}^{-3}$.

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21. A semiconductor wafer, comprising:
an SiC substrate having an n-type

35 conductivity; and

an AlGaM layer having an n-type conductivity formed on said SiC substrate with a composition

1 represented as $\text{Al}_x\text{Ga}_{1-x}\text{N}$,
wherein said AlGaIn layer has a carrier
density in the range between $3 \times 10^{18} - 1 \times 10^{20} \text{cm}^{-3}$,
and
5 wherein said compositional parameter x is
larger than 0 but smaller than 0.4 ($0 < x < 0.4$).

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22. A semiconductor wafer as claimed in
claim 21, wherein said substrate contains carriers of
said first conductivity type with a concentration
15 level in the range from $1 \times 10^{18} - 1 \times 10^{20} \text{cm}^{-3}$.

20 23. A semiconductor wafer as claimed in
claim 21, wherein said compositional parameter x of
said buffer layer is less than 0.09 ($x < 0.09$).

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24. An optical semiconductor device as
claimed in claim 21, wherein said substrate has a
(0001)Si surface of SiC and wherein said buffer layer
30 is formed on said (0001)Si surface in intimate contact
with said substrate.

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